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Dane

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[54] **ORTHOTIC ARM JOINT**

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[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration,** Washington, D.C.

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[52] **U.S. Cl.** ..... **307/149,** 214/1 CM, 308/174

[51] **Int. Cl.**..... **B25j 3/00**

[58] **Field of Search**.... 128/77; 307/149; 214/1 CM; 74/425; 308/174

[56] **References Cited**

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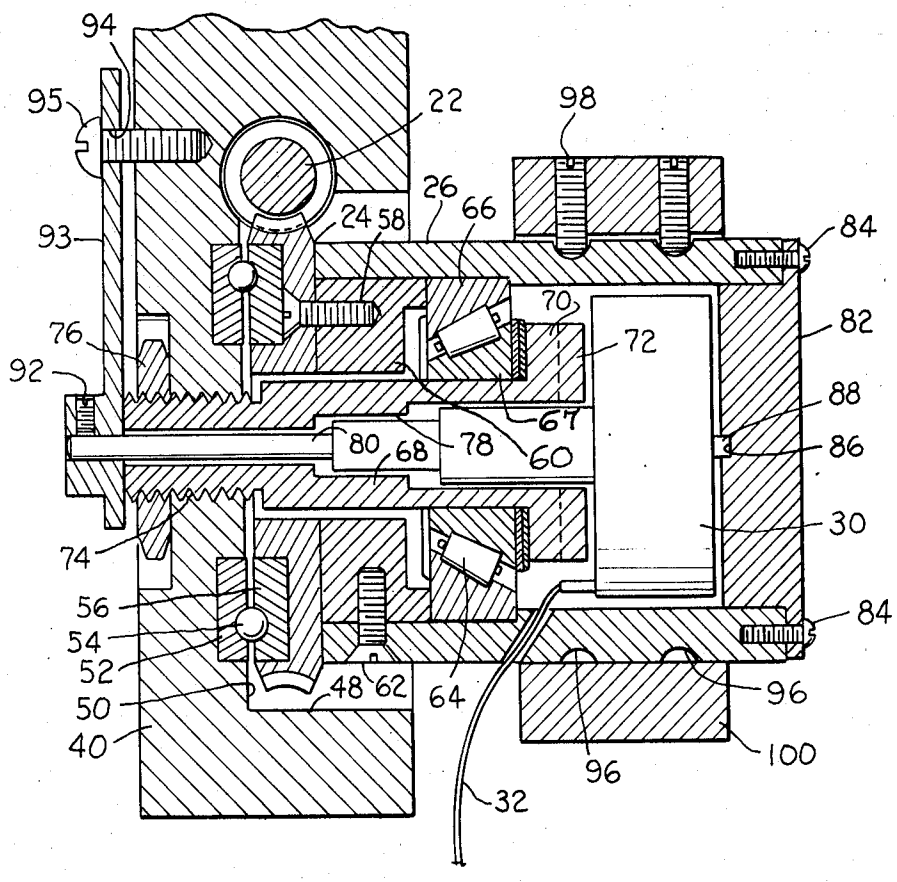
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[57] **ABSTRACT**

An improved orthopedic (orthotic) arm joint that can be used in various joints of mechanical arms. The arm joint includes a worm, which is coupled to an electric motor for rotating a worm gear carried within a rotatable housing. The worm gear is supported on a thrust bearing and the rotatable housing is supported on a radial thrust bearing. A bolt extends through the housing, bearings, and worm gear for securing the device together. A potentiometer extends through the bolt, and is coupled to the rotatable housing for rotating therewith, so as to produce an electrical signal indicating the angular position of the rotatable housing.

6 Claims, 4 Drawing Figures



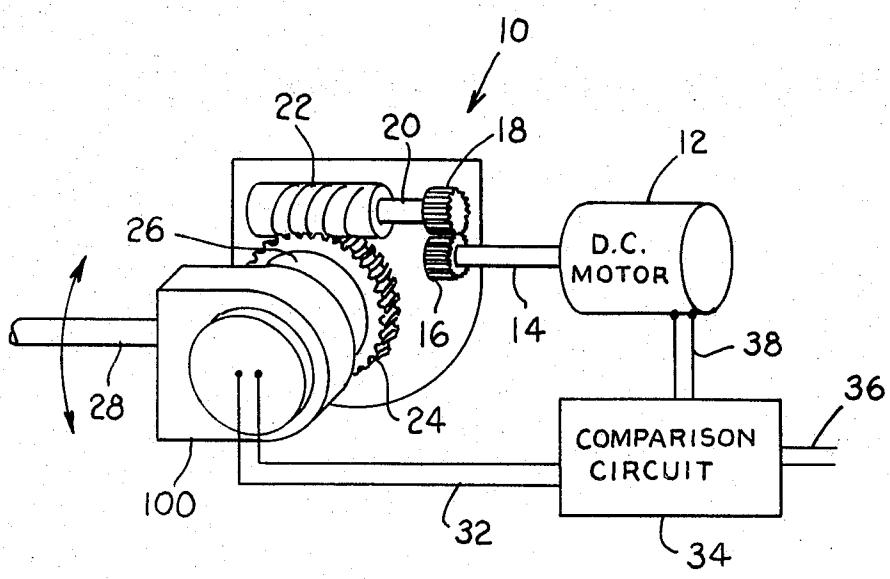

10
22
20
18
12
26
D.C. MOTOR
16
14
38
28
24
36
COMPARISON CIRCUIT
100
32
34

Fig. 1.

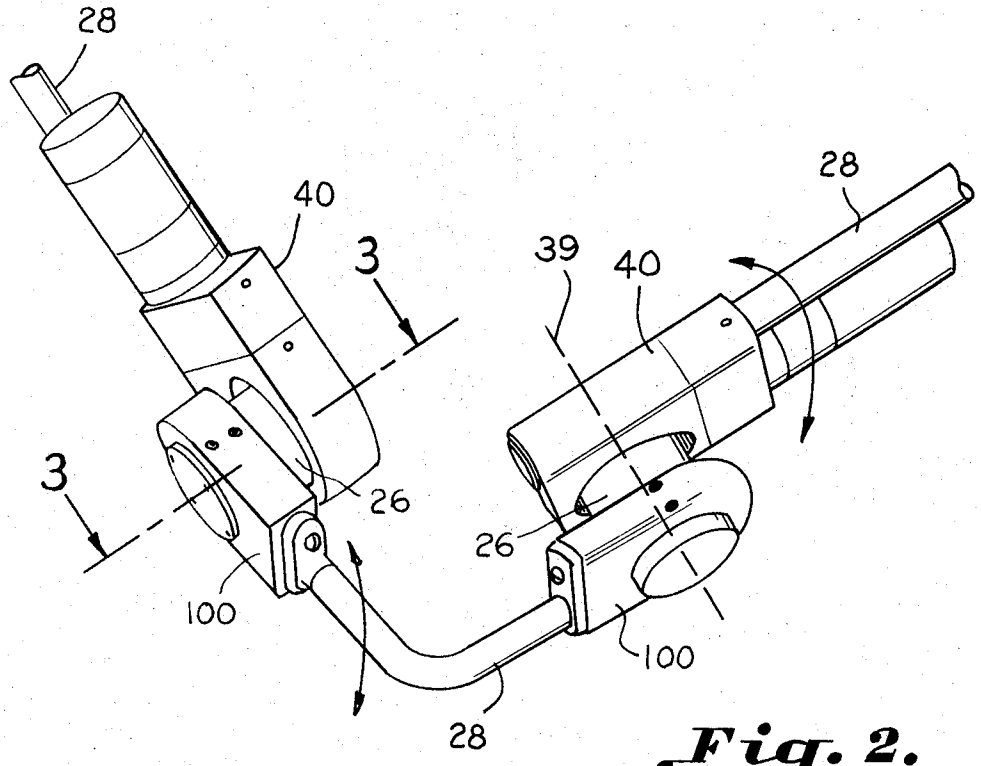

28
40
3
39
40
28
3
26
26
100
100
28

Fig. 2.

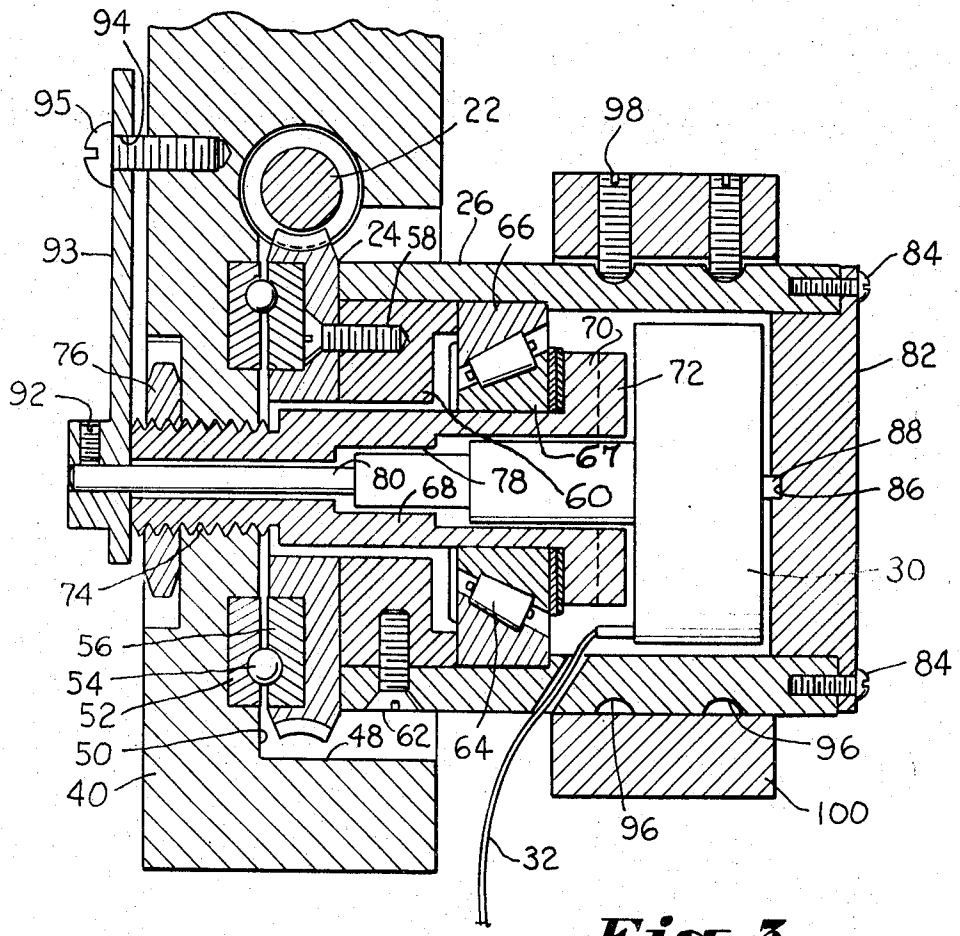

94
95
22
98
26
66
24
58
93
84
70
76
72
82
92
88
67
80
68
78
60
86
74
30
56
54
52
50
40
48
62
64
84
96
96
100
32

Fig. 3.

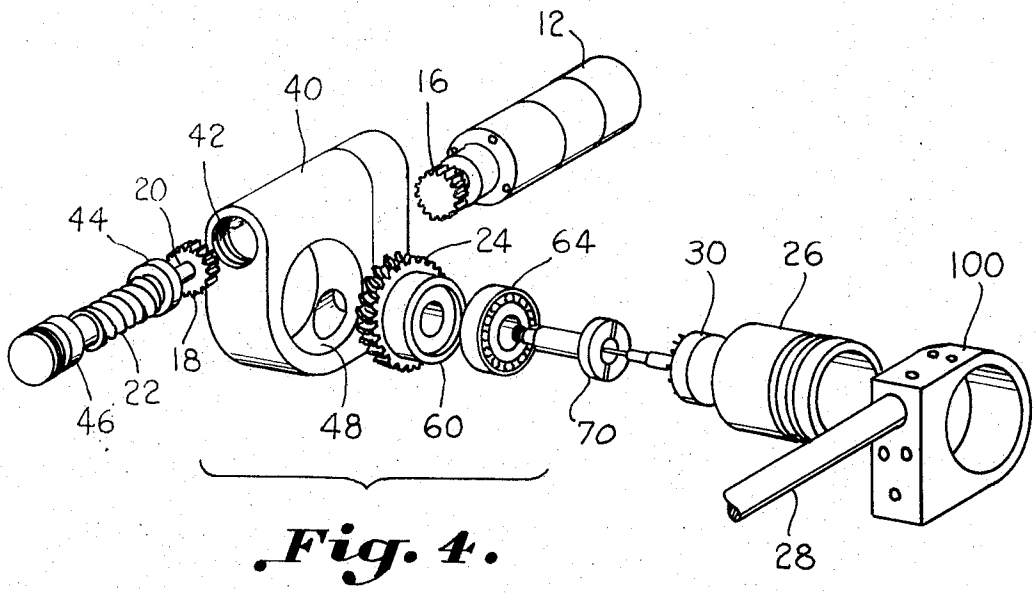

12
40
16
42
20
44
24
64
30
26
100
18
22
46
48
60
70
28

Fig. 4.

ORTHOTIC ARM JOINT

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government, and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to an orthotic arm joint, and more particularly to an arm joint which can be accurately rotated for manipulating various objects.

Joints have been utilized in mechanical arms for providing movement of the arm responsive to electrical signals. These joints have generally been limited in the amount of stress that can be applied thereto. The joints have been used in space exploration wherein, a master mechanical arm located on earth is used for manipulating a similar arm located on the moon or in space vehicles. By sending electrical signals from the master arm the mechanical arm located at the remote station can be manipulated to perform various functions, such as collecting and testing soil samples, etc. As these tests have been performed the importance of developing mechanical devices that are capable of doing ordinary work using screw drivers, drills, soldering irons, etc., have become apparent. In order to perform the desired work the operation of the mechanical joints must be very accurate. The mechanical joint constructed in accordance with the present invention has been utilized in orthopedic arm joints used by patients who are completely paralyzed except for movement of their head and tongue. The patients, by use of their tongues, have been able to manipulate the mechanical arms equipped with the novel joint so as to perform functions, such as writing, feeding themselves, and other tasks normal to persons not paralyzed.

SUMMARY OF THE INVENTION

The invention comprises a joint for use in mechanical arms mounted in a fixed housing. A worm gear supported on a thrust bearing is carried within the fixed housing, and has a spacer positioned adjacent thereto. Positioned on the opposite side of the paper is a radial thrust bearing having an inner race and an outer race. A bolt having a shank portion extends through the radial thrust bearing, the spacer, the worm gear, and the thrust bearing for engaging the fixed housing. A rotatable housing is supported on an outer race of the radial thrust bearing, and has an inner end fixed to the worm gear for rotating therewith. An outwardly extending arm is coupled to the rotatable housing. An electric motor is used for rotating the worm gear responsive to being energized so that the arm can be manipulated by selectively energizing the electric motor. A potentiometer is mounted within the rotatable housing for generating an electrical signal indicating the angular position of the rotatable housing relative to the fixed housing.

Accordingly, it is a general object of the present invention to provide an improved orthotic arm joint.

Another important object of the present invention is to provide a joint that can be accurately manipulated and utilized in mechanical systems to perform work which requires considerable load.

Still another important object of the present invention is to provide a mechanical joint which will sustain substantial bending forces.

Still another important object of the present invention is to provide a relatively simple and maintenance free joint that can be manipulated by use of electrical signals.

These and other object and advantages of the invention will become apparent upon reference to the following specification, attendant claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic block diagram of an arm joint constructed in accordance with the present invention located within a circuit that can be used in remote control systems,

FIG. **2** is a perspective view showing a pair of arm joints mounted to provide movement in two different directions,

FIG. **3** is a sectional view taken along line **3—3** of FIG. **2** illustrating the details of an arm joint constructed in accordance with the present invention, and

FIG. **4** is a perspective exploded view of an arm joint constructed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1** of the drawings there is illustrated an arm joint generally designated by the reference character **10.** The arm joint is under control of an electric motor **12** which drives an output shaft **14.** Positioned on the end of the output shaft is a gear **16** which meshes with a gear **18** carried on a shaft **20** upon which a worm **22** is mounted. The worm **22** engages a worm gear **24** forming part of the arm joint which in turn is used for rotating an outer housing **26** for manipulating an outwardly extending arm **28.** A potentiometer **30** is carried within the rotatable housing **26** and generates an electrical signal which is fed over leads **32** for indicating the angular position of the arm **28.**

When the joint is being used in a master-slave system the signals being generated by the potentiometer **30** are fed into a comparison circuit **34** for being compared with electrical signals coming in on leads **36** from the master system. The comparison circuit **34,** which can be any suitable conventional comparison circuit, generates an error signal which is fed through leads **38** to the D.C. motor for causing the motor to rotate the shaft **14** a certain angular distance. Such, in turn, causes the arm **28** to rotate to the desired position.

When it is desired to provide movement in more than one direction, two of the joints may be coupled together, such as illustrated in FIG. **2.** Normally, such a coupling is provided when it is desired to simulate the movement inherent in a shoulder joint. The joint shown on the right in FIG. **2** permits rotation about an axis **39,** whereas, the joint shown on the left permits rotation about an axis corresponding to the line **3—3** in FIG. **2.**

Referring in more detail to FIGS. **3** and **4** of the drawings, a fixed housing **40** constructed of any suitable metallic material, has a hole (not shown) provided for receiving the gear **16** carried on the end of the shaft **14** of the D.C. motor **12.**

Another longitudinal bore **42** is provided for receiving shaft **20** upon which worm **22** is carried. The gear **18**, which is carried on the end of the shaft **20**, meshes with gear **16** carried on the end of the shaft **14** so that the D.C. motor **12** can rotate the worm **22**. Suitable bearings **44** and **46** are provided for rotatably supporting the shaft **20** within the bore **42**.

The housing **40** has an enlarged recess **48** provided therein. The recess **48** terminates in a rear wall **50**. A groove is provided in the rear wall **50** for receiving an inner race **52** of a thrust ball bearing **54**. An outer race **56** of the thrust bearing **54** is suitably carried within the circular groove provided in the face of the worm gear **24**. Positioned on the other side of the worm gear **24**, and attached thereto by screws **58**, is a spacer **60**. The spacer **60** is, in turn, secured to the cylindrically shaped rotatable housing **26** by means of screws **62**. Flush against an outer edge of the spacer **60** is a radial thrust bearing **64** which has an outer race **66** engaging an inner wall of the rotatable housing. An inner race **67** is supported on a shank portion **68** of an elongated bolt **70**. The bolt **70** has an enlarged head **72** which abuts against the radial thrust bearing **64** with the shank portion **68** extending therefrom through the radial thrust bearing **64**, the spacer **60**, the worm gear **24**, and a bore **74** provided in the wall **50** of the fixed housing **40**. The bore **74** has threads therein for engaging threads carried on the outer end of the shank portion of the bolt **70**. A lock-nut **76** is threaded on the end of the bolt **70** for fixing the bolt to the housing **40**.

An elongated bore **78** extends longitudinally through the bolt **70** for receiving a shank portion **80** of the potentiometer **30**.

A cap **82** is secured to the outer end of the cylindrical rotatable housing **26** by means of screws **84**. A groove **86** is provided in the inner surface of the cap **82** for receiving an elongated ridge **88** carried on an enlarged head of the potentiometer **30** so as to permit the head of the potentiometer **30** to be rotated with the rotatable housing **26**. Wires **32** coming from the enlarged head of the potentiometer **30** extend through an opening in the rotatable housing **26** so that such can be attached to a suitable voltage source and output device. When the enlarged head of the potentiometer is rotated relative to the shank portion **80** thereof, such varies the output signal of the potentiometer. The setting of the potentiometer may be adjusted by rotating an external arm **93**, which is connected by a setscrew **92**, to the shank portion **80** of the potentiometer. The arm **93** has an arcuate slot **94** therein, of approximately **90** angular degrees through which a bolt **95** extends. The inner end of the bolt **95** threadably engages the fixed housing **40**. By unscrewing the bolt and rotating the arm **93** a predetermined number of degrees the potentiometer **30** can be adjusted.

The rotatable housing **26** has grooves **96** provided therein for receiving an inner end of nylon setscrews **98**. The nylon setscrews **98** are threaded through holes provided in a collar **100** which extends around the rotatable housing.

The reason that nylon setscrews are utilized for securing the collar **100** to the rotatable housing **26** is to prevent damaging the joint if too great a load is applied to the outwardly extending arm **28** carried by the collar **100**. When the load exceeds a predetermined force the nylon screws permit the collar **100** to slip on the rotatable housing **26**.

It is noted that the inner race **67** of the radial thrust bearing **64** is supported on the shank portion **68** of the bolt **70** so as to permit the rotatable housing **26** to rotate freely relative to the bolt.

In summarizing the operation of the joint, when an electrical signal is applied to the D.C. motor **12** such causes the shaft **14** to rotate a predetermined number of degrees. The rotation of the shaft **14**, in turn, causes the worm **22** to be rotated. The rotation of the worm **22** causes the worm gear **24** to be rotated. When the worm gear **24** is rotated the housing **26** is rotated therewith. The arm **28** carried by the collar **100**, which is attached to the housing **26**, is also rotated a predetermined number of degrees. Thus, it can be seen that by selectively energizing the electric motor **12** the arm **28** can be manipulated. It is noted that when the housing **26** is rotated the enlarged head portion of the potentiometer is rotated therewith relative to the shank portion **80**. This causes an electrical signal to be fed out over the wires **32** indicating the angular position of the arm **28**. Therefore, by comparing the electrical signal produced by the potentiometer **30** with signals produced by a potentiometer carried in a master arm corrective signals can be applied to the motor **12** so that the arm **28** is in the same position as the arm carried by a master unit.

By utilizing a radial thrust bearing **64** spaced from a thrust bearing **54**, as shown in FIG. **3**, the arm joint is more capable of handling bending forces applied thereto. When the joint is used in an orthopedic arm it is not necessary to utilize the potentiometer **30**, since the position of the devices attached to the arm **28** can be physically observed, rather than relying on an electrical signal for indicating the angular position thereof.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

What is claimed is:

1. A joint for use in a mechanical arm comprising:

a. a fixed housing;

b. a thrust bearing including an inner race connected to said fixed housing and an outer race;

c. a worm gear;

d. said outer race being carried in said worm gear;

e. a spacer connected to said worm gear on an opposite side from said thrust bearing;

f. a radial thrust bearing having an inner race and outer race;

g. a bolt having a shank portion extending through said inner race of said radial thrust bearing, said spacer, said worm gear and said thrust bearing for engaging said fixed housing;

h. a rotatable housing supported on said outer race of said radial thrust bearing having an inner end fixed to said worm gear;

i. an outwardly extending arm coupled to said rotatable housing; and

j. an electric motor having a shaft coupled to said worm gear for rotating said worm gear responsive to being energized,

k. whereby said arm is manipulated by selectively energizing said electric motor for driving said worm gear which in turn rotates said rotatable housing.

2. The joint set forth in claim 1 further comprising:

a. a potentiometer enclosed in said rotatable housing;

b. means for supplying electrical voltage to said potentiometer;

c. said potentiometer having a movable element attached to said rotatable housing for rotating therewith for varying the voltage output thereof, and

d. a shank portion of said potentiometer coupled to said fixed housing;

whereby when said rotatable housing is rotated the angular position thereof can be determined by the output voltage from said potentiometer.

3. The joint as set forth in claim 1 further, comprising:

a. circumferential grooves carried on an outer surface of said rotatable housing;

b. a collar carried on said rotatable housing having threaded holes extending therethrough in alignment with said circumferential grooves;

c. nylon setscrews extending through said holes in said collar into said grooves in said rotatable housing for locking said collar relative to said rotatable housing; and

d. said arm being mounted on said collar so that when a force is applied to said arm greater than a predetermined value, said setscrews permit said collar to slip on said rotatable housing minimizing damage to said joint.

4. The joint as set forth in claim 1, wherein said inner race of said radial thrust bearing is supported on said shank portion of said bolt.

5. The joint as set forth in claim 2 wherein:

a. said bolt has an elongated axial bore extending therethrough; and

b. said shank portion of said potentiometer extending through said elongated axial bore for engaging said fixed housing.

6. The joint as set forth in claim 3 wherein:

a. said electric motor has a rotatable output shaft;

b. a gear carried on said rotatable output shaft;

c. a worm rotatably carried in said fixed housing meshed with said worm gear, and

d. said gear rotating said worm responsive to energizing said electric motor.

* * * * *